

DALTON (J. C.)

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TRICHINA SPIRALIS:

A LECTURE DELIVERED AT THE COLLEGE OF PHYSICIANS AND SURGEONS, FEB. 20, 1869.

By JOHN C. DALTON, M.D.,
PROFESSOR OF PHYSIOLOGY AND MICROSCOPIC ANATOMY.

[Taken from the MEDICAL RECORD, April 15, 1869.]



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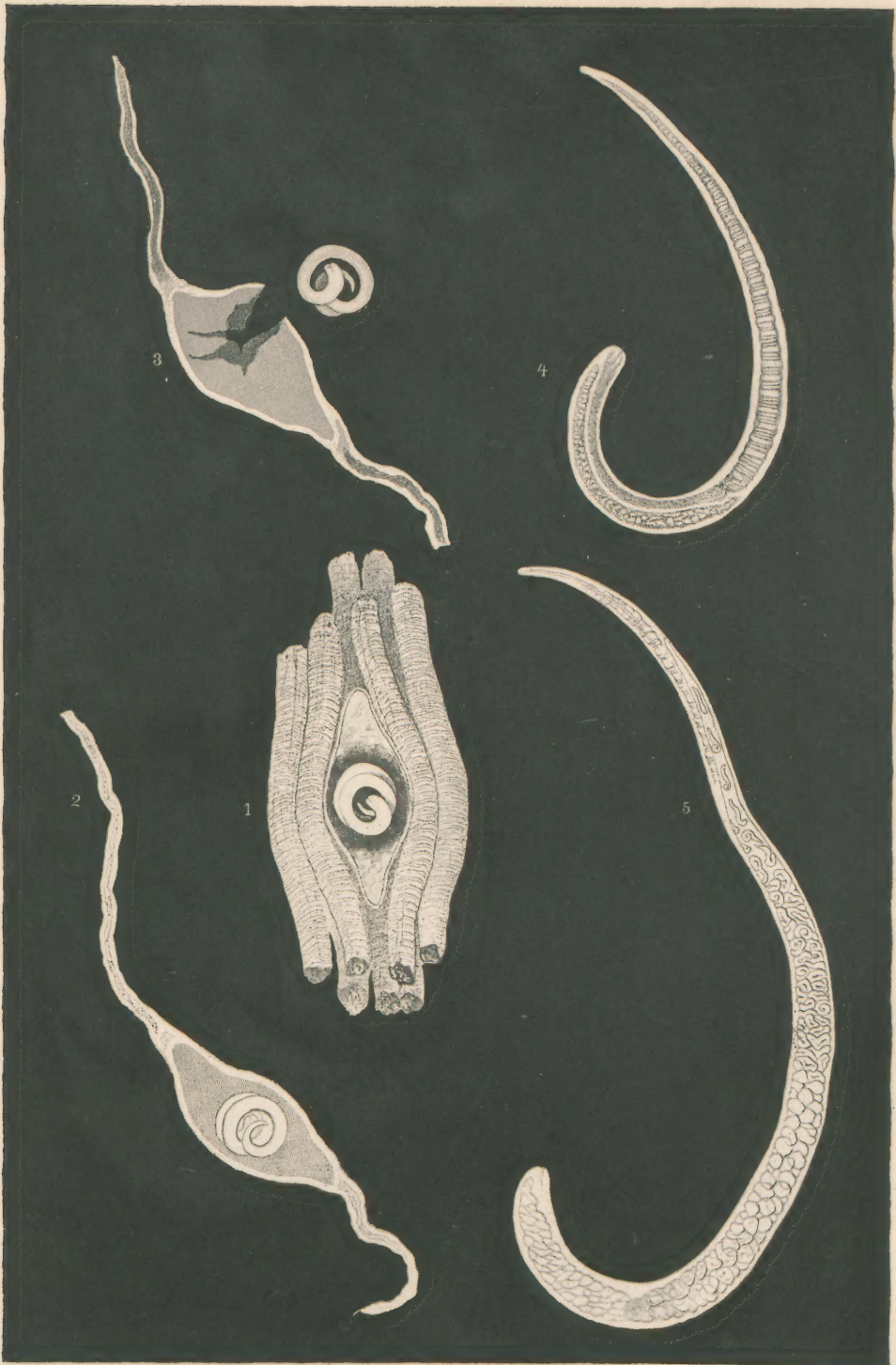


FIG. 1. OLD ENCYSTED TRICHINA FROM HUMAN MUSCLE.

FIG. 2. RECENT ENCYSTED TRICHINA FROM HAM.

FIG. 3. CYST RUPTURED BY PRESSURE AND TRICHINA EXPELLED.

FIG. 4. ENCYSTED TRICHINA EXTRACTED FROM THE CYST AND UNWOUND.

FIG. 5. ADULT FEMALE TRICHINA WITH YOUNG FROM SMALL INTESTINE.

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GENTLEMEN:—The subject of Trichinosis, to which our attention will be directed to-day, is remarkably interesting in three points of view. First of all, it is a disease of extreme importance with regard to its possible frequency, the fatality which it sometimes manifests, and the ease with which, at any time, it may show itself in a community where it has been previously unknown; at the same time it is a preventable disease; and in the third place, it is especially interesting as an instance of a malady which has been discovered, so to speak, suddenly, within a comparatively short period, although undoubtedly it has existed unrecognized from time immemorial.

Trichinosis, as you are all now aware, is a disease produced by the infection of the muscular system by a minute parasite, which has received the name of *trichina spiralis*. The existence of *trichina spiralis* in the muscles of the human subject has been known for over thirty-five years. As early as 1832, little bodies were discovered in human muscle, which upon examination were found to consist of ovoid sacs, and a few years later it was found that each one of these sacs contained a minute round worm coiled spirally upon itself. This discovery was first made in the muscles of a hospital patient. In that case it was found that the trichinæ were exceedingly numerous and scattered throughout the body, in the substance of the voluntary muscles. Since that time they have been noticed, in many instances, in persons who have died from accidental causes, from pneumonia, from phthisis, and various other affections: from diseases, in a word, which would appear to be entirely disconnected with the existence of the parasites; so that notwithstanding the great abundance of the parasites, medical men were forced to the conclusion that they exerted no deleterious influence whatever upon the subjects inhabited by them.

I have here a specimen, which I took myself from the human subject, some ten years ago. It is the rectus femoris muscle, and, like the other voluntary muscles in this case, it is full of these parasites. You will see here the regular appearance of the trichinæ as they are usually seen, and as they were exclusively known previous to about the year 1855. Look at this muscle very carefully; you will find, just visible to the naked eye, minute ovoid bodies situated between the muscular fibres, having an opaque envelope and a transparent, but apparently dark-colored, centre. On dissecting out these bodies with needles, it is found, as I have said, that they consist of an ovoid sac, and inside this sac the worm lies, spirally coiled up. This is the old encysted trichina, such as you see in this drawing. (Vide Plate, Fig. 1.)

Between the fibres of the muscle, and lying parallel with them, is the ovoid sac, somewhat pointed and yet slightly rounded at its two ends, and swollen in the middle, where the worm is coiled up. Now the trichina is coiled in such a manner inside the sac, as to make about two turns and a half upon itself. One extremity of the worm is blunt and rounded, the other is more

pointed, and the two lie so near each other that half a turn more would bring them together. These bodies, although so minute, are yet visible to the naked eye on close examination in such specimens as this; because, as you readily find, under the microscope, they are partly solidified by a calcareous deposit in the cavity of the sac. This deposit is of a gritty and almost crystalline texture, brittle, breaking upon firm pressure, and is composed, probably, of phosphate of lime, slowly deposited, so as to give to the extremities of the sac an opaque appearance and a very firm consistency.

This is the condition in which the trichina presented itself in all specimens brought to the observation of medical men, for some twenty-five years after its first discovery. They were cases of old, encysted trichinæ. All that was known about them was that they were encysted, that they did not exhibit any distinct sexual apparatus, and that they did not appear to produce any distinct symptoms by their presence in the human organism.

But between the years 1850 and 1860, certain experimenters in Germany undertook to examine the natural history of this parasite more closely. They did so by administering portions of muscle infected with it to the lower animals; and they found—especially Leuckart, who was the most successful in these investigations—that the worms, apparently so insignificant in size, and so incomplete in development so long as retained in the muscular system, become further developed when introduced into the intestine of another animal. After a short time the sexual apparatus appears, copulation takes place, the female produces living young, and these young penetrate finally into the muscular tissue of the second animal, and there domicile themselves for an indefinite time. In this way somewhat more definite ideas were acquired with regard to the natural history of the worm, as found in the inferior animals. By a continuation of these experiments, it was found that this infection of the muscular system with trichina may show itself in the pig, the cat, the rat, the mouse, the rabbit, and, I believe, one or two other species of the inferior animals.

So far, nothing more had been learned with regard to trichinosis as constituting a disease in the human subject. The new era in this respect opened with the year 1860. At that time an epidemic of trichinosis occurred in Germany. The members of a family living in Dresden were taken sick with symptoms similar to those of acute rheumatism, mingled with those of typhoid fever. One of them, a servant-girl, died, and on examination it was found that her muscles were filled with trichinæ. The attending physician and Professor Virchow tried the experiment of administering the trichinous muscles to a rabbit, and found that the rabbit became infected with the parasite, and died in about four weeks' time. The infected tissues of this rabbit were administered to a second, which became infected in the same manner, and died, like the first, in about four

weeks. Finally, a third rabbit was fed with the flesh of the second, with a similar result. These experiments show that the disease, as it exists in the human subject, may be transmitted to the lower animals; that it may be transmitted indefinitely from one animal to another, the parasites passing alternately from the intestines to the muscular system, and again from the muscular system to the intestines. These are the general outlines of the origin and course of the disease known as trichinosis.

Now let us see what are the details of the anatomical structure and physiological development of the worm itself.

I have said that, as you examine the trichinae in those cases where they have existed in the muscles for an indefinite period, where they have become encysted, and the cavity of the cyst has been invaded by calcareous deposit, it is not easy to make out their anatomical structure. But in cases where the disease is recent, and particularly where it can be traced to the recent use of trichinous flesh as food, the anatomy of the worm can be made out with more distinctness. Such a case happened in this city about five years ago. Some sailors, on board ship, were taken sick while in port with symptoms resembling those noticed in the Dresden family, similar to those of typhoid fever and acute rheumatism combined. It was found that the disease originated, in their cases, from eating raw pork or bacon. About the same time other cases of the disease became developed in persons living permanently in the city; and it was found in these cases that the difficulty could be traced to the use of ham imperfectly cooked.

A portion of this ham came into my possession, and in examining it I found not only that the meat was trichinous, but also that the parasites were in a decidedly different condition from that which they exhibit in cases of long standing. The first peculiarity was that the cysts in which the worms were contained, instead of having definite and rounded ends, gradually tapered off into long and slender prolongations, the extremities of which could not be reached, being entangled in an intricate manner with the muscular fibres. In these drawings you see represented the cysts containing the trichinae, as found in the ham. (Fig. 2.) In this case the cyst is evidently a hollow, fusiform tube, consisting of a transparent and structureless, but well-developed, membrane, containing the worm coiled up, as you see. From the two extremities of this fusiform cyst run off the prolongations. It is very important to ascertain exactly the structure of these prolongations. It is evident that they are tubular, and that their cavity is nearly continuous with that of the sac containing the worm. Not quite so, however, for it can be seen that a membranous partition runs across where the prolongations begin, so that the worm is enclosed in a distinct cavity; and that the prolongations are tubes of much smaller calibre, but were apparently at some previous time connected with the central cavity. Now this central cavity contains a transparent fluid; the worm is, therefore, lying free in the interior of the sac, not connected with its membranous walls; this can be demonstrated by breaking open the sac by a slight pressure between the glass plates. It ruptures, and discharges the worm, which escapes in such a manner as to show that it lay before perfectly free within the cavity of the sac. (Fig. 3.) The worm still remains coiled up, after its escape, and you will usually find much difficulty in uncoiling it sufficiently to examine its structure. No operation in microscopic anatomy requires more patience than this; for its firm folds must be unwound without rupturing any of its parts, in such a manner as to give

you a fair view from one extremity to the other. (Fig. 4) This done, the trichina, at this stage of development, is found to be a worm one twenty-eighth of an inch in length; its anterior extremity or head is tapering and pointed; the body very gradually enlarges as you pass from the anterior extremity towards the middle, and about the middle acquires its greatest diameter, which it retains throughout the rest of its extent, terminating posteriorly in a round, blunted extremity. The alimentary canal runs longitudinally throughout the whole length of the worm, there being a mouth at the anterior or pointed extremity, and an anus at the posterior or rounded end. About the junction of the middle with the posterior third of the parasite, the calibre of the alimentary canal suddenly contracts, then enlarges again, and afterward remains reduced to about one-third its original size. The only other organ visible at this time is one which occupies, together with the alimentary canal, the posterior third of the worm; an organ apparently tubular in character, rounded at either end, and filled with rather large and tolerably well-defined cellular bodies. This evidently is the sexual apparatus, such as it exists at this time.

The characters which I have given are sufficient to define the encysted trichina as taken from the muscles. Suppose now a portion of muscular flesh, filled with trichinae in this condition, be taken as food by the human subject or administered to one of the lower animals. On arriving in the small intestine, the worms are found to be perfectly free, for the muscular tissues in which they were imbedded, as well as the cysts in which they were contained, are digested in the stomach, so that within twenty-four or forty-eight hours you find an abundance of free trichinae in the cavity of the duodenum. At once they begin to increase in size, so much so that very soon, usually by the fourth or fifth day, they have become three or four times as large as before. They have now arrived at the adult condition. At the same time the sexual apparatus, before so incomplete, has become perfect, and the copulation of the sexes takes place. I have myself, on several occasions, found in the intestine of the rabbit the two sexes in copulation, the male fastened upon the female at the orifice of the generative apparatus. The eggs having been impregnated, as the animal is viviparous, the female soon becomes full of the young brood.

In this drawing you see these parts as I have just described them. (Fig. 5.) Instead of the intestine now taking up the whole of the anterior two-thirds of the body, and a great part of the posterior third, you find that the sexual apparatus is by far the most prominent organ in the interior of the body of the female; and as soon as the young have arrived at the period of development here represented, they begin to move forward to the terminal duct of the generative apparatus. This can now be seen very clearly, running from the ovary forward to a point quite near the anterior extremity of the worm. The young are very numerous. I do not know that it has been calculated how many a single female is capable of producing, but they are probably very numerous. The young, discharged in this way into the cavity of the small intestine, begin to penetrate through its mucous membrane, by a boring process, passing undoubtedly through the entire thickness of the intestinal walls. This causes a great deal of irritation, which is the first symptom of trichinosis. It is usually sufficient to produce a considerable degree of pain, and not unfrequently a smart attack of diarrhoea.

After passing through the walls of the intestine, the worms disperse in every direction, and from that time you begin to find them in the muscular tissue throughout the body. There they domicile themselves, and,

within a fortnight after the symptoms have begun to manifest themselves in the human subject, you will find them almost everywhere, scattered throughout the voluntary muscles. They are still very small, having increased but little in size during their transit, so that when they first arrive in the muscular tissue they are not more than about 1-140th or 1-120th of an inch in length. They soon, however, become encysted, and then increase very considerably in size. At first, however, they are not enclosed in distinct sacs, but are found contained in the interior of long tubes.

We have already seen that, although the encysted trichina is contained in a sac or cavity of its own, this sac is often connected with prolongations running out from each extremity; and in the human muscle, within the first fortnight of infection, the young worms are found contained in swollen tubes. This is the condition of the worm as it was found in the muscles of the human subject on the thirteenth day of illness in a case which I had the opportunity of examining. The worm, you see, is not free, but is contained in the interior of a tube, swollen or fusiform at the point where the worm lies partly coiled up. The worm is not stationary at this time, but by gentle pressure can be made to move from one end to the other of the swollen portion of the tube. By about the end of the first fortnight its coils assume a considerable degree of regularity, and the worm then reaches that condition which has given it its name of *trichina spiralis*.

We have now described the worm as domiciled in the muscular tissue. The next question is, How did it get there, and what is the nature of this tube which it now inhabits, and which is hereafter to become its cyst? These are points with regard to which some doubt still remains. Most of the German observers are agreed that this tube is a muscular fibre; they believe the worm passes from the intestine to the remotest regions of the body by boring its way through the intermuscular cellular substance; and that if examined on its first arrival there, it is perfectly free; that it then penetrates the substance of the muscular fibre, producing atrophy and degeneration of its substance, until the fibre becomes converted into the tube with prolongations which I have described. On the other hand, it is possible that the worm, instead of working its way through the intermuscular cellular tissue, may also be transported by the circulation; for if it can bore through the walls of the intestine, it can, of course, also penetrate the blood-vessels, and it might thus finally reach the left side of the heart, and be sent with the current of the circulation to every part of the body. However, it is certain that the young trichinae arrive at the muscular tissue, either by working their way through the intervening cellular tissue or by distribution by the blood-vessels. They very soon present themselves in the interior of these swollen tubes, which may be either capillary vessels that have become plugged, by coagulation of the blood, or by deposit of exuded material excited by the presence of the worm; or may be muscular fibres that have undergone degeneration and atrophy from its presence. Soon the tube containing the parasite suffers a further alteration. An exudation takes place around the worm, so that that part of the tube containing it is shut off from the rest; and the remainder of the tube becomes atrophied into slender, tapering prolongations. After some years these also entirely disappear, and you see only an ovoid sac without prolongations; and finally you may have the cavity of the cyst invaded by a calcareous deposit, as I have already described—the last peculiarity of the degenerated cyst.

Now all these changes in the history of the trichina

have been seen in the human subject; the development of the young in the body of the female; their discharge from the mother's body into the intestine; their penetration of the walls of the intestine and dispersion to the muscular tissue throughout the body; their domiciliation in the interior of the tubular cavities, and the change of the tubular cavities into ovoid cysts; the calcification of these cysts; and the quiescent and dormant condition of the worm as the result.

Now to what symptoms does this accident give rise? As I have already said, within the first ten days there is irritation of the intestines. In some instances this irritation is very great; and the greater it is, the more favorable the prognosis, as a general rule. After eating trichinous flesh, the patient generally begins to suffer within the first week, sometimes within two days. Now, if the irritation of the intestine be extreme, so that frequent and abundant evacuations are produced, the chances are very great that all, or nearly all, of the parasites will be discharged from the intestine. If so, the patient is safe. But if the irritation be not very marked, time is allowed for the young trichinae to penetrate the intestinal walls, and enter the muscular tissue—from the end of the first to the end of the second week. This is the most dangerous period, the second stage of the disease. There is general pain and soreness, and oedematous swelling throughout the muscular system. At the same time typhoid symptoms manifest themselves; the patient is debilitated, his pulse rapid, skin hot, tongue and lips dry, and his general appearance closely resembles that of a patient with typhoid fever.

The passage of the worms into the muscular tissue, and the changes taking place there, are very apt to produce symptoms which result in the patient's death at or before the end of the fourth week. By that time the worms have become completely encysted, and after this the symptoms of irritation begin to disappear. The muscular system becomes habituated, as it were, to the presence of the parasite; and after a while the symptoms all subside; the patient can move his limbs as before, and then considers himself as entirely recovered.

How long may the worms remain in this quiescent condition in the interior of the muscular system? In 1863 Prof. Langenbeck of Berlin was operating upon a patient for a tumor of the neck, situated upon the surface of the sterno-mastoid muscle: in dissecting it off, the fibres of this muscle were disclosed, and it was noticed that their surface was covered with minute white specks. These attracted so much attention that a portion was excised and submitted to the microscope, when the specks were found to be encysted trichinae. After the patient's recovery, minute inquiries were made to ascertain at what time he had become infected. The result was that no such attack could be traced to a period less remote than eighteen years before. At that time, viz., in 1845, the patient, with several associates, was serving upon a committee of inspection of the public schools. After the inspection in a certain district, the committee partook at the village inn of a lunch, consisting, in part, of ham. Very soon after, all the members of the committee were taken sick with symptoms similar to those which we now know to be attributable to trichinosis. Two of them died, and the signs of poisoning were so marked that the innkeeper was arrested and held under this charge for a considerable time. Although finally the circumstances were not found sufficient for his conviction of the crime, yet they were considered as so much against him, and the prejudices of the community were so excited in consequence, that he was obliged at last to leave the place. On going over all the history of the case, so

far as it could be ascertained at that time, it left an undoubted impression on the minds of the medical men who made the investigation, that at the time before-mentioned, viz., in 1845, the members of the committee were infected with trichinæ from the ham used for their lunch; that two of them had died in consequence; and that Prof. Langenbeck's patient had recovered, and the worms remained encysted for eighteen years afterward. How much longer they may thus remain I do not know, but I see no reason why they should not last for the remainder of the patient's life. They produce in this condition no interference with the health, and hardly seem to interfere even with the vigor of the muscles.

This was the condition in which the trichinæ were nearly always found, prior to the year 1850, and from this fact it was supposed that the trichina was a harmless parasite. Such are the chief circumstances connected with the physiological history of the worm.

There still remains one question of a very important nature,—How great is the liability of the community at the present time to be infected, and what measures can be taken to prevent it?

The pig seems to be the animal naturally the most liable to trichinosis. He is certainly more liable to this disease than any other animal used for food, neither the sheep nor the ox being subject to it. It has been found in this country, by investigations in Chicago in 1866, that of all the pigs brought to market in that city, one in fifty is infected with trichina. This shows that we are all in danger of becoming infected by the use of pork, unless measures be taken, in preparing the meat, to destroy the vitality of the worms. Smoking and salting will not do this effectually. Only thorough cooking is to be relied on as a safeguard. It is remarkable that most, if not all of the cases of trichinosis in this country, thus far have occurred among the Germans. This is because they have the habit, not otherwise common here, of eating ham, sausages, and even sometimes fresh pork, nearly or quite in the uncooked state. To kill the worms the ham must not only be salted and smoked, it must be cooked, and cooked thoroughly. Now, if you bear in mind that one pig in fifty is infected with trichina, you will perhaps think many times before putting between your lips a piece of pork, or ham, or sausage in the raw state; you will be certain that it is cooked; and not only that, but thoroughly cooked. One of the worst cases of trichinosis that has come under my observation was caused by eating pork chops which were rare or slightly underdone. Now, these chops were probably well enough cooked on the outside; but on the inside they were red and juicy, and the danger was precisely the same as if the patient had taken the meat entirely raw. In order to destroy the vitality of the trichina the meat should be subjected to a temperature of 212° F. Now, if you boil a ham for half an hour, or even an hour, you do not necessarily subject all parts of it to this temperature. In the central parts of the ham the temperature will not rise to that point unless the boiling has been long continued. I speak of this particularly, as it is a very important matter. A temperature of less than 160° F. does not destroy the trichina. As shown by direct experiment, therefore, a piece of trichinous meat, any part of which has not been raised to or above this point, is just as dangerous as if it were taken in the raw state.

These are the chief points of importance in regard to the trichina and trichinosis. The disease is fatal enough, frequent enough, and revolting enough to induce us to take all possible measures to prevent it, and I do not think anything is sufficient for this but

a personal examination of every piece of pork, ham, bacon, or sausage used as food, to see that every part of it has been subjected to a thorough cooking process.

One other point still I should like to speak of. We have seen that the disease shows itself occasionally in the human subject, but very frequently in the pig. Now, how is it, under these circumstances, that the continuance of the species of trichina spiralis is provided for by nature? We have here an animal that arrives at maturity in the intestine of the human subject. In that situation the female bears living young in consequence of the individual having eaten pork filled with the encysted and quiescent trichinæ. So long as these remain encysted and quiescent in the pig's muscles they remain practically undeveloped and practically sexless. This flesh is eaten by the human subject. In the intestines of the human subject the worms are set free, the females are impregnated and bear young, and these scatter themselves throughout the body. Now, when these young have, in their turn, in the human subject arrived at the period of quiescence, how are they ever to get back to the intestine of a living animal, and so become capable of continuing their species?

I presume that the mode by which the race is continued is this: Suppose we start with the pig infected with quiescent and sexless trichina. This pig is butchered. You know that butchering establishments are the abundant resort of rats, which feed upon the refuse scraps of meat, and of course these after a time become infected with trichina. The worms are developed in the intestine of the rat, and produce living young. These not only infect the muscular system of the rat, but they are also discharged with the fæces. These fæces become mingled with the food of the pig,—an animal, as we know, not very fastidious with regard to his food, and consequently subject to several parasitic diseases,—and thus the round of development of the trichina is completed. Again, its perpetuation is provided for by a similar round between the cat and the mouse. The mouse becomes infected by feeding upon refuse meat, and the cat by devouring the mouse or rat. We have therefore the natural history of the animal, embracing in each case two different phases, in one of which it undergoes an active development, in the interior of the intestine, while in the other it assumes the quiescent form, becoming encysted in the substance of the muscular system.

There are other points of considerable interest with regard to the rapidity with which the human subject may be infected, the great number of persons who may become infected by eating the product of a single slaughtered animal, and the degree of fatality attending the disease. Enough, however, is known to convince us that the affection is a very frequent one, and liable to be exceedingly fatal, or if not fatal, to produce prolonged and exhausting disease.

Much would be effected if all pork offered for sale in the market could be subjected to inspection; and this has been done in some parts of Germany; pork being liable to infection not only with trichina, but also with cysticercus, producing tape-worm in the human subject. Such inspection would undoubtedly prove very useful. Still it would not afford complete protection, unless carried out with an amount of detail which would in all probability prove practically unattainable. The only absolute protection, therefore, must be that exercised by the individual for himself. He must see that he never uses for food any kind or preparation of pork in any form not so thoroughly cooked as to destroy every possible vestige of parasitic life.

